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Integration of the Hydrologic Simulation Program—FORTRAN (HSPF) Watershed Water Quality Model into the Watershed Modeling System (WMS)

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Preface

The work reported herein was conducted as part of the Water Quality Research Program (WQRP), Work Unit 32989. The WQRP is sponsored by the Headquarters, U.S. Army Corps of Engineers (HQUSACE), and is assigned to the U.S. Army Engineer Research and Development Center (ERDC) under the purview of the Environmental Laboratory (EL). Funding was provided under Department of the Army Appropriation No. 96X3121, General Investigation. Dr. John W. Barko was Program Manager for the WQRP. Mr. Robert C. Gunkel, Jr., was Assistant Manager for the WQRP. Program Monitors during this study were Messrs. Frederick Juhle and Lewis Smith, HQUSACE.

This report was prepared by Dr. Patrick N. Deliman, Water Quality and Contaminant Modeling Branch (WQCMB), Environmental Processes and Effects Division (EPED), EL, ERDC, and Mr. Willard J. Pack and Dr. E. Jim Nelson, Brigham Young University, Environmental Modeling Research Laboratory, Department of Civil and Environmental Engineering. Ms. Lillian Schneider and Dr. Carlos E. Ruiz, WQCMB, were technical reviewers for this report.

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1   HSPF Interface

HSPF Model

The Hydrological Simulation Program—FORTRAN (HSPF) is an analytical tool designed to allow the engineer to simulate hydrology and water quality in natural and man-made systems (Bicknell et al. 1993). HSPF is used to apply mathematical models to simulate the movement of pollutants through watersheds (Donigian and Huber 1990). This analysis helps predict possible environmental problems in the watershed. With the growing need to care for and monitor the effects of man on the environment, it became apparent that a method for rapid analysis of those effects was needed. A watershed water quality model review conducted by the U.S. Army Engineer Waterways Experiment Station (WES) recommended the implementation of HSPF into the Watershed Modeling System (WMS) modeling interface (Deliman, Glick, and Ruiz 1999).

The WMS interface creates a way for the user to input a multitude of parameters into the input file and then to run HSPF to get the required output (Environmental Modeling Research Laboratory 1998). The input parameters are linked to all the tools within WMS, including automated basin delineation and parameter definition using a graphical user interface.

HSPF Interface and WMS

The objective of the interface developed in WMS is to provide graphical representation of HSPF data, as well as automate the definition of many of the required parameters. Many of the basic variables required for HSPF input are computed as part of WMS's basic functionality; additionally, specialty functions have been added to WMS to enable the usage of HSPF directly with data output from WMS. Some of these operations will be discussed in the following section.

WMS overview

WMS is a comprehensive graphical modeling environment for hydrologic analysis. The Engineering Computer Graphics Laboratory of Brigham Young University (BYU), in cooperation with WES, has developed WMS over the past several years to be a modeling environment suitable for setting up and running several hydrologic models such as HEC-1, TR20, NFF, F0601, and the Rational Method. Recently, cooperation between BYU, AquaTerra, and WES has led to

the development of the tools necessary to use HSPF directly with WMS. Defining the required parameters for HSPF can be accomplished in one of several ways.

Lumped parameter models, such as HSPF, may be set up in WMS with no digital terrain data at all. WMS can be used to create topological representations of watershed, or hydrologic trees, such as the one seen in Figure 1 below. In this tree, squares represent basins, circles represent collection points, and arrowed lines represent diversions (relief drains). Once the topology of the watershed has been defined in this way, the user through a series of user-friendly dialogs may input the required input parameters for any of several models. This method of defining hydrologic models is offered by several software packages. However, a major shortcoming of this method is that it models a conceptual watershed; therefore, the user must define the physical and geometric data necessary for input. Computation of these data can prove to be a daunting task with respect to the input required by HSPF.
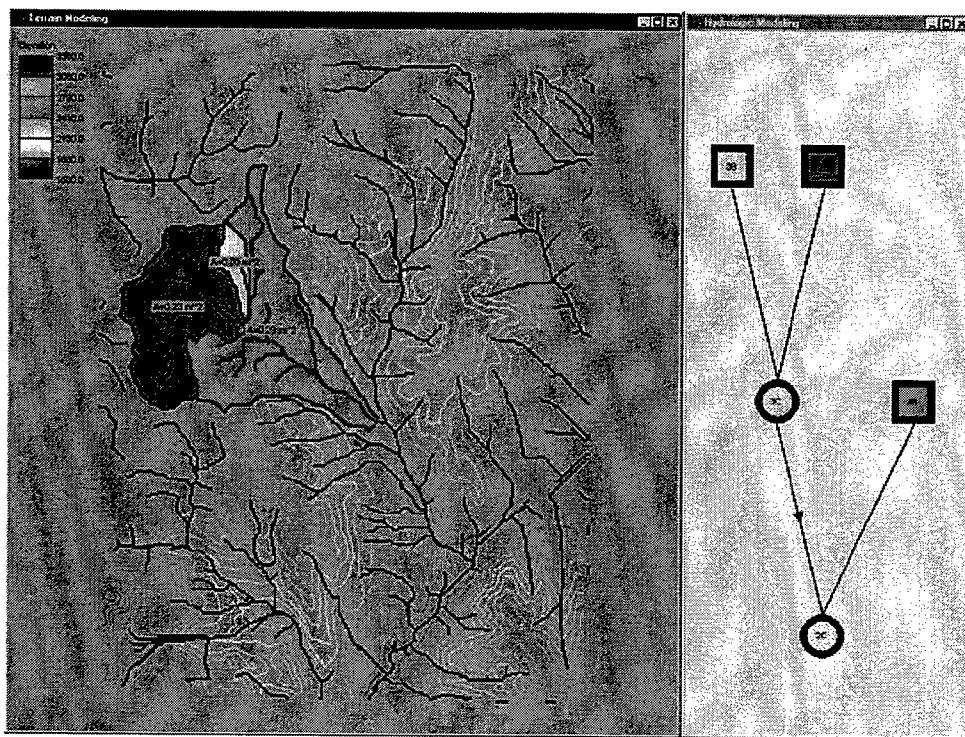
Figure 1.   WMS topological tree and map

The strength of WMS as a modeling environment lies in the digital terrain modeling functions available to the user. These functions can be used to create terrain models of watersheds using Geographic Information Systems (GIS) data, gridded Digital Elevation Models (DEMs), or Triangulated Irregular Networks (TINs). Any of these data can be used to automatically delineate watersheds, streams, and subbasins. Once boundaries and streams are created, geometric attributes such as area, slope, and runoff distance can be computed automatically. Furthermore, the latest version of WMS provides functions to define parameters

such as soil type, land use, and rainfall by overlaying GIS data (gridded or vector) on the watershed model.

When a digital terrain model is created, as discussed above, a topological tree representation of the watershed is also created. However, the majority of the model parameters are now defined and assigned to the tree components. The user can then review defined data in dialogs and set any additional input parameters quickly.

Any one of several methods may be used to create digital terrain models. For a complete discussion of WMS functionality in this area, please see the Watershed Modeling System Reference Manual and Tutorials. These documents provide procedures for watershed delineation, as well as step-by-step examples of watershed and hydrologic model definition.

HSPF in WMS

Several custom dialogs and menu options have been developed in WMS to facilitate the definition of HSPF input data. Furthermore, HSPF can be launched directly from WMS through menu options. These menus can be found in the *Hydrologic Modeling Module* under the HSPF heading. Saving and reading HSPF input files are also available in this menu.

Whenever an HSPF file is saved or HSPF is launched, an HSPF input file is written to the disk. This file may be viewed and edited using any text editor.

WMS can calculate several parameters that are used in HSPF as well as divide the basins into segments allowing for multiple land uses within a basin segment (Figure 2).
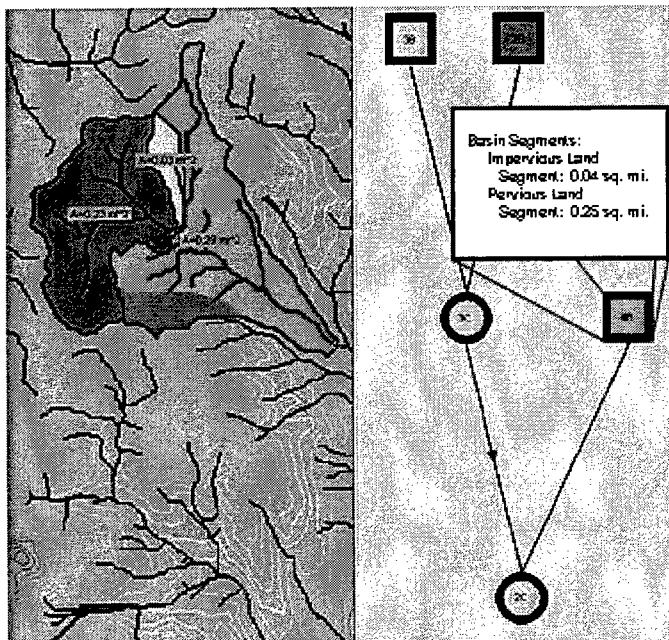
Figure 2.   Basin segments within WMS

Getting Started

In order to access the input parameters for basin segments, the HSPF data must be initialized for the entire watershed. This is a simple procedure that involves the click of a button within the *HSPF Global Options* dialog box. Once the data are initialized, the user may access the various dialog boxes within the HSPF interface.

The following sections will describe the dialog boxes involved in the interface and will explain the expected input parameters. It is recommended that the user look to the HSPF documentation to receive a complete description of how HSPF uses the parameters.

HSPF Global Options

The *Global Options* dialog box (Figure 3) is used to initialize the HSPF data for every hydrologic unit of the hydrologic tree and to set up the overall simulation. This dialog box contains the text edit fields in which the user will input the file names to be used. The start and end time for the simulation as well as the output level is entered in the *Global Options* dialog box as well.
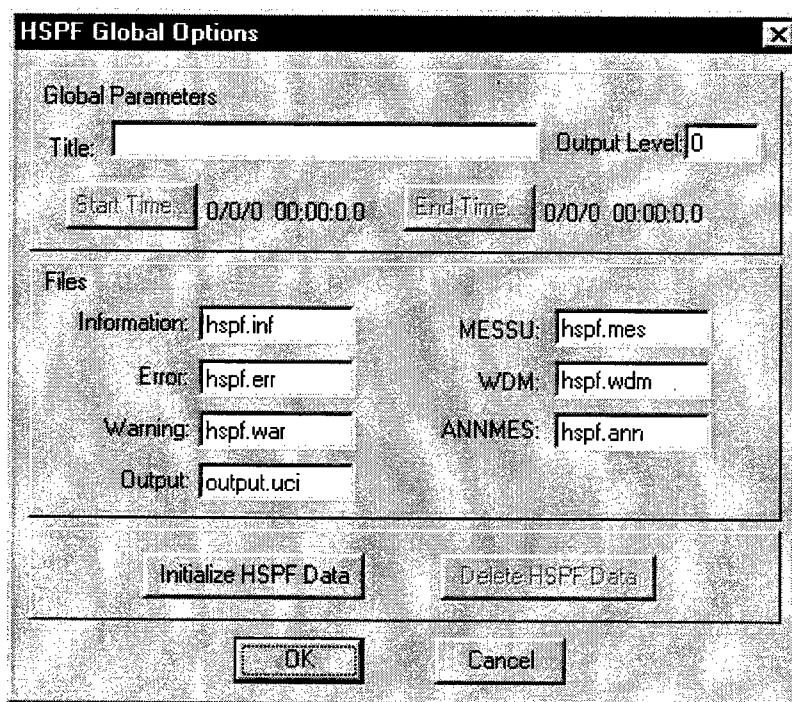
Figure 3.   HSPF global options dialog box

Initialize HSPF data

The data for HSPF must be initialized before the user can access it. By clicking on the *Initialize HSPF Data* button within the *Global Options* dialog

box, the user initializes all HSPF data within the watershed. Many features within the HSPF interface will be dimmed and remain dimmed until the user initializes the HSPF data.

File names

The file names must include the extension since many of these files have different extensions. Enter the names of the input, error, warning, MESSU, WDM, ANNMES, and output files. These will all be written to the UCI file and will be created or accessed when HSPF is run. Default file names are created by WMS and appear in the text edit fields upon opening the dialog box. These may be changed to fit the simulation without adversely affecting the program. The file extension must be included.

Start and end times

The start and end time buttons can be clicked on, and the start and end times for the HSPF simulation may be entered into the dialog box. HSPF will recognize year, month, day, hour, and minute intervals. Anything more precise will be ignored by HSPF.

Output level

The output level is a flag that governs the quantity of output information created while running HSPF. The value ranges from 0 to 10, 0 being minimum output and 10 being maximum output. This flag does not affect warning or error messages.

Entering/Editing HSPF Attributes

Attributes or parameters for all land segments of the topologic tree are defined and/or edited using the *Edit HSPF Attributes* dialog (Figure 4). This dialog is accessed by selecting the *Edit HSPF Attributes...* command from the *HSPF* menu or when *HSPF* is the active model (see Figure 2), by double-clicking on a basin or an outlet from either the *Graphics* or *Tree Window*.

If a basin or outlet is selected before issuing the command, then data for that hydrologic unit are loaded for editing. The dialog lists the HSPF parameters, which can be edited by selecting the corresponding button. When a hydrologic unit is selected (basins/outlets), only the items that correspond to parameters associated with that unit are active; all others are dimmed. For example, when a basin is selected, all items under the Reach/Reservoir Data heading are dimmed.

Once the *Edit HSPF Attributes* dialog is up, it will remain open until the user selects the *Done* button. This enables the user to switch between basins or outlets quickly and define the necessary parameters without closing and opening the dialog for each hydrograph station. The remainder of this section will describe each item in the *Edit HSPF Attributes* dialog.
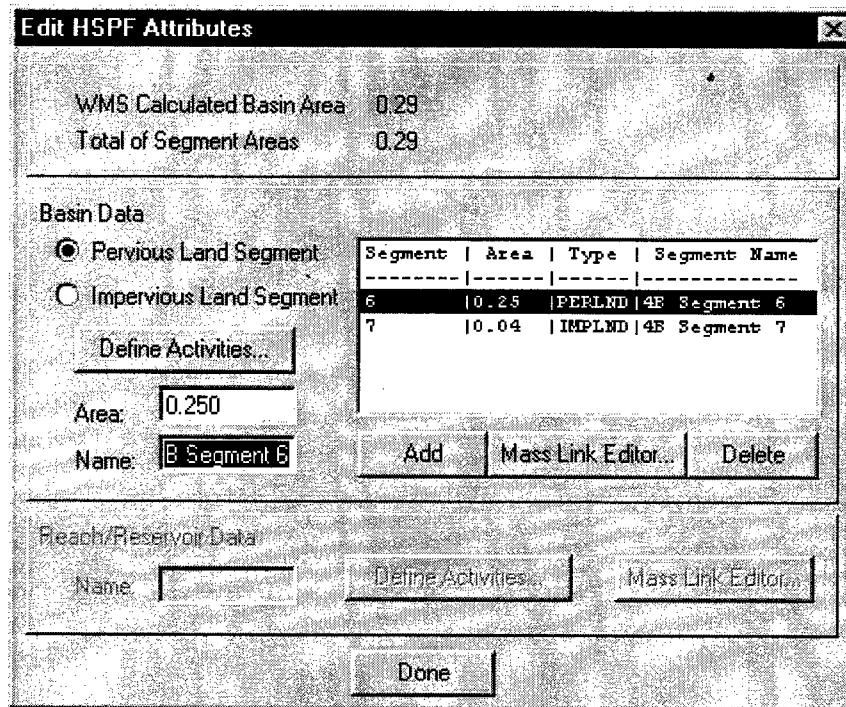
Figure 4.   Edit HSPF attributes dialog box

Basin data

The portion of the *Edit HSPF Attributes* dialog box that handles basin data is mainly a starting point for entering the rest of the basin segment's HSPF data. The text window lists the land segments within the selected basin. When a segment is selected within the text window, it becomes possible to edit the name and area of the particular basin segment. The area section, above the basin section, shows the sum of the areas of the individual basin segments as well as the area of the basin as calculated by WMS if a terrain model was used to calculate basin data. A radio group is located in the basin area of the dialog box to allow the user to specify whether the basin is pervious or impervious. Between the boxes for editing the segment name and area and the radio group is a button that will take the user to the rest of the input dialog boxes for the basin segment. All other basin segment data are input through the impervious or pervious dialog boxes. Below the text window listing the basin segments, buttons may be found to add or delete segments within the basin. The new basin segments default to pervious land segments with no specified area.

Reach/reservoir data

The portion of the *Edit HSPF Attributes* dialog box that handles the input data for the RCHRES units is located at the bottom of the *Edit HSPF Attributes* dialog box. Within that small section of the dialog box, the name of the RCHRES may be edited. The button located next to the edit field accesses a dialog used to define the various RCHRES parameters.

Mass link editor

The *Edit HSPF Attributes* dialog box contains two buttons to the mass link editor, one in the basin area and one in the RCHRES area. The mass link editor is a dialog box (Figure 5) that is used to create links between two hydrologic units of the topologic tree. Those links are in the form of time series data as well as a unit conversion factor. The mass link editor has three mass links in it upon startup, which should cover the basic transfer of water from a basin segment to a reach as well as one reach to another. Within the mass link editor, it is possible to create more mass links by simply selecting the appropriate options in the various combo boxes and inputting a value as the conversion factor then hitting the *Add Link* button.


```
Mass Link Editor                                        [X]

Volume | Group | Member | Factor | Target | Group | Member
-------|-------|--------|--------|--------|-------|--------
PERLND   PWATER  PERO    0.8333  RCHRES  INFLOW  IVOL
IMPLND   IWATER  SURO    0.8333  RCHRES  INFLOW  IVOL
RCHRES   HYDR    ROVOL           RCHRES  INFLOW  IVOL
```

Volume Name: PERLND   Multi Factor: 0.00   Target Name: RCHRES
Group: PWATER   Add Link   Group: INFLOW
Member Name: PERS   Import   Member Name: IVOL
                       Export

OK   Cancel
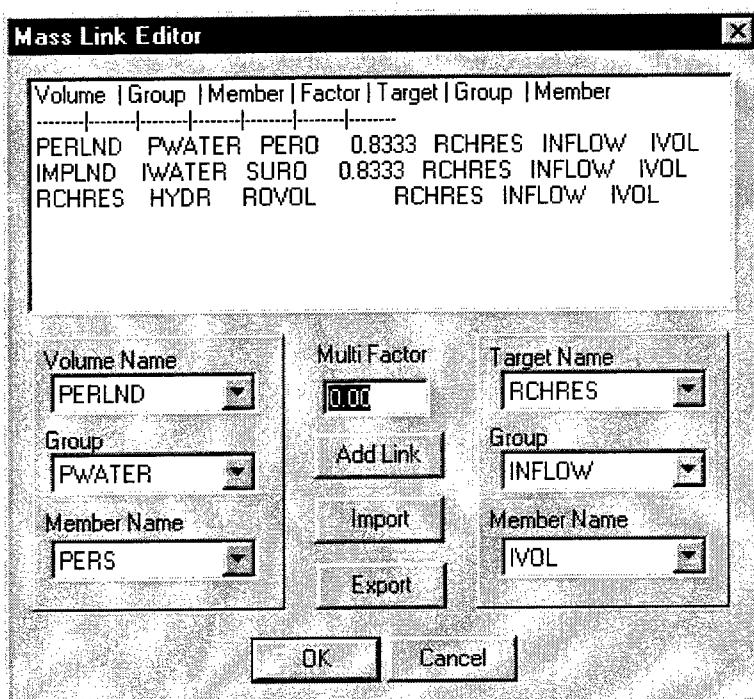
Figure 5.   Mass link editor

If a number of mass links are to be used for many simulations, it would be wise to save the mass links to a file that would be read in any time they are needed. The *Export* button allows the user to specify a file name, and then the mass link window is saved as ASCII text to that file. The *Import* button allows the user to read in a previously saved mass link file.

To assign a mass link to a given element of the hydrologic tree, simply open the mass link editor, available either through the *HSPF* menu or on the *Edit HSPF Attributes* dialog box, select a mass link, and hit *OK* on the mass link editor. The mass link that is selected upon closing the editor is assigned to the selected element of the hydrologic tree.

Basin Activity

Basins may be divided into segments to more accurately depict the land use within the watershed. By default, a basin is created with a single segment that comprises the entire basin. HSPF data are input into the basin segment. Further, the segment may be designated as a Pervious Land Segment or as an Impervious Land Segment. This distinction tells HSPF to look for certain input parameters for segment characterization.

Pervious land segment activity

Pervious Land Segments receive input into three different modules: PWATER, SEDMNT, and PQUAL. The other modules that appear in the *Activity* dialog box will remain dimmed because they are currently not included in the interface. The other modules may be included in future versions of WMS. To activate a module, click the toggle box in the *Pervious Land Activity* dialog box (Figure 6). This will undim the button that leads to the dialog box for that module. Each of these modules will be explained in greater detail in later sections.
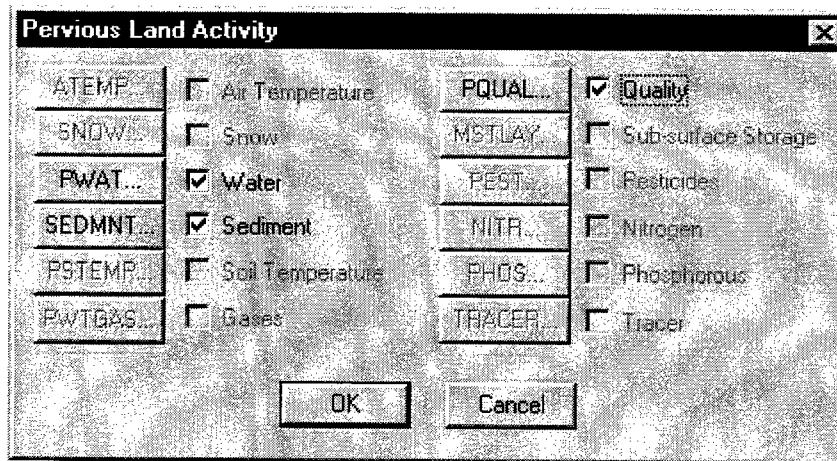
Figure 6.   Pervious land activity dialog box

Impervious land segment activity

Impervious Land Segments receive input into seven different modules: general input, ATEMP, SNOW, IWATER, SOLIDS, IWTGAS, and the IQUAL modules. This interface currently includes the general input, IWATER, SOLIDS, and IQUAL modules. To activate a module, click the toggle box in the *Impervious Land Activity* dialog box (Figure 7). This will undim the button that leads to the dialog box for that module. Each of these modules will be explained in greater detail in later sections.
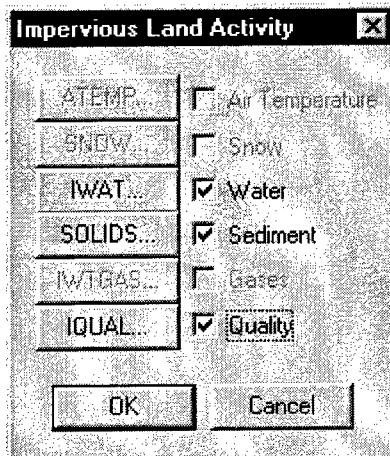
Figure 7. Impervious land activity
dialog box

RCHRES Activity

A RCHRES will receive input into five different modules: HYDR, ADCALC, HTRCH, SEDTRN, and the RQUAL modules. The RQUAL module is divided into four sections: OXRX, NUTRX, PLANK, and PHCARB input. The other modules that appear in the *Activity* dialog box are not included in the current version of the interface but may be included in later versions of WMS. To activate a module, click the toggle box in the *Reach/Reservoir Activity* dialog box (Figure 8). This will undim the button that leads to the dialog box for that module. Each of these modules will be explained in greater detail in the following sections.
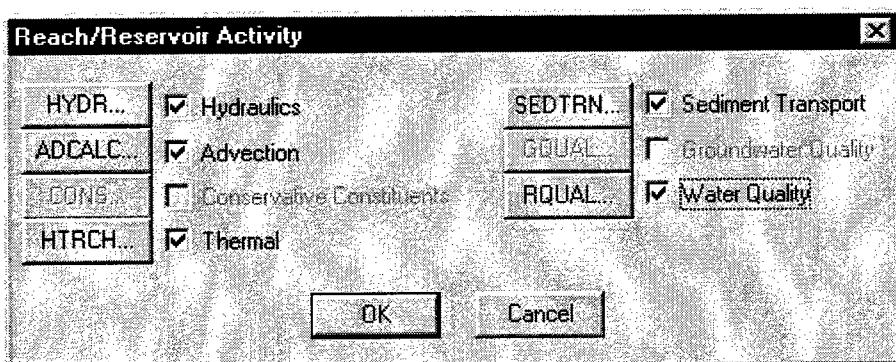
Figure 8. Reach/reservoir activity

Pervious Land Parameters

To access the *Pervious Land Parameters* dialog box (Figure 9), the user must press the PWAT... button in the *Pervious Land Activity* dialog box, explained above. The *Pervious Land Parameters* dialog box lets the user enter the main parameters for the pervious land segment. The segment parameters are all listed in the dialog box, and the help strings include a range of values that are reasonable. Some parameters require a single value for the entire simulation, and others are allowed to vary monthly. There are some buttons to input monthly values for the variable parameters. The parameters within the Pervious Land Parameters dialog box are divided into five categories: PWAT PARM1, PWAT PARM2, PWAT PARM3, PWAT PARM4, and Initial Conditions.
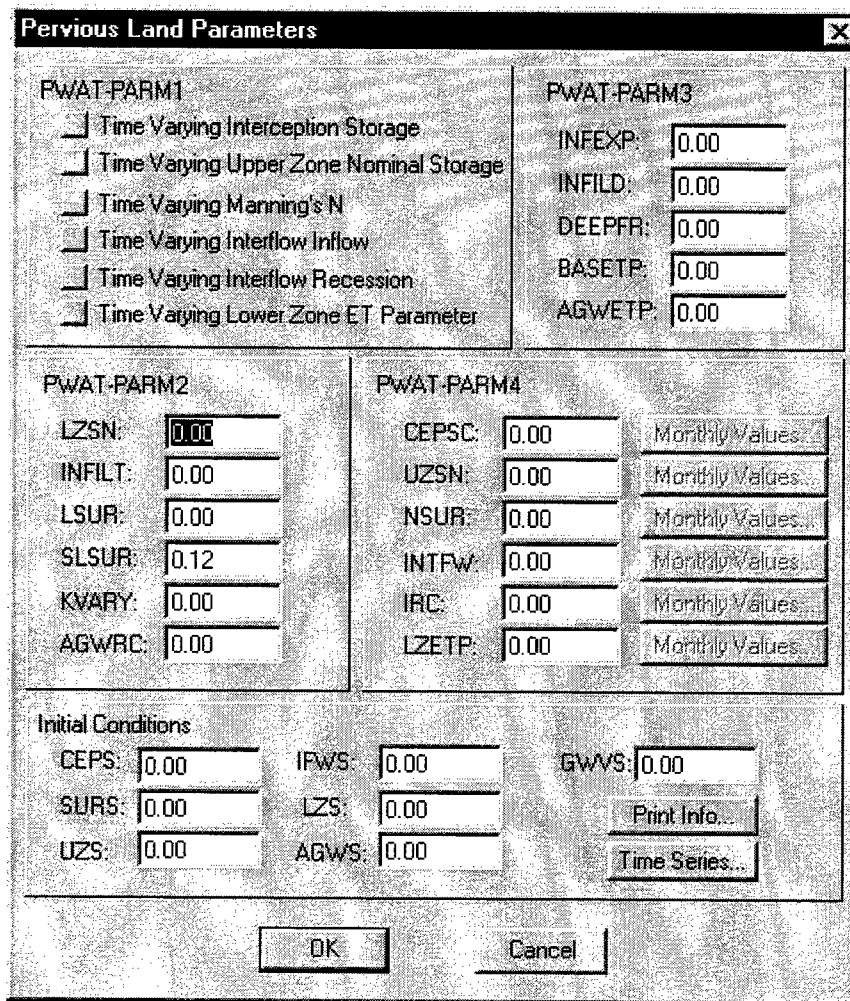
Figure 9. Pervious land parameters dialog box

PWAT PARM1

The values in this section tell HSPF what to expect in other areas of the pervious land segment data.

Toggle boxes in the PWAT PARM1 section of the dialog box represent all the variables preceded by a 'V'. When the toggle box is selected, the appropriate *Monthly Values...* button becomes undimmed allowing the user to input monthly values for the given parameter.

- VCSFG informs HSPF that interception storage capacity varies throughout the year.

- VUZFG informs HSPF that the upper zone nominal storage varies throughout the year.

- VNNFG informs HSPF that Manning's n for the overland flow plane varies throughout the year.

- VIFWFG informs HSPF that the interflow inflow parameter varies throughout the year.

- VIRCFG informs HSPF that the interflow recession constant varies throughout the year.

- VLEFG informs HSPF that the lower zone E-T parameter varies throughout the year.

PWAT PARM2

The values located within the PWAT PARM2 section of the *Pervious Land Parameters* dialog box are explained below.

- LZSN is the lower zone nominal storage.

- INFILT is an index to the infiltration capacity of the soil.

- LSUR is the length of the assumed overland flow plane

- SLSUR is the slope of the assumed overland flow plane.

- KVARY is a parameter that affects the behavior of groundwater recession flow, enabling it to be nonexponential in its decay with time.

- AGWRC is the basic groundwater recession rate if KVARY is zero and there is no inflow to groundwater (rate of flow today/rate yesterday).

PWAT PARM3

The values located in the PWAT PARM3 section are explained below.

- INFEXP is the exponent in the infiltration equation.

- INFILD is the ratio between the max and mean infiltration capacities over the pervious land segment.

- DEEPFR is the fraction of groundwater inflow that will enter deep (inactive) groundwater and, thus, be lost from the system as it is defined in HSPF.

- BASETP is the fraction of remaining potential E-T that can be satisfied from baseflow (groundwater outflow) if enough is available.

- AGWETP is the fraction of remaining potential E-T that can be satisfied from active groundwater storage if enough is available.

PWAT PARM4

The values defined in the PWAT PARM4 section of the dialog box are explained below. These parameters may vary throughout the year. If the corresponding flag is selected in the PWAT PARM1 section, appropriate dimming occurs and monthly values are expected for the parameter. Simply click the button corresponding to the variable parameter and enter values in the *Monthly Values* dialog box.

- CEPSC is the interception storage capacity.

- UZSN is the upper zone nominal storage.

- NSUR is Manning's n for the assumed overland flow plane.

- INTFW is the interflow inflow parameter.

- IRC is the interflow recession parameter. Under zero inflow, this is the ratio of interflow outflow rate today/rate yesterday.

- LZETP is the lower zone E-T parameter. It is an index to the density of deep-rooted vegetation.

Initial conditions

This area of the *Pervious Land Parameters* dialog box allows the user to input the initial water storages. The values are explained below.

- CEPS is the interception storage.

- SURS is the surface (overland flow) storage.

- UZS is the upper zone storage.

- IFWS is the interflow storage.

- LZS is the lower zone storage.

- AGWS is the active groundwater storage.

- GWVS is the index to groundwater slope; it is a measure of antecedent active groundwater inflow.

Impervious Land Parameters

To access the Impervious Land Parameters dialog box (Figure 10), the user must press the *IWAT...* button in the Impervious Land Activity dialog box, explained above. The Impervious Land Parameters dialog box lets the user enter the main parameters for the impervious land segment. The segment parameters are all listed on the dialog box, and the help strings include a range of values that are expected. The parameters within the Impervious Land Parameters dialog box are divided into three categories: IWAT PARM1, IWAT PARM2, and Initial Conditions.
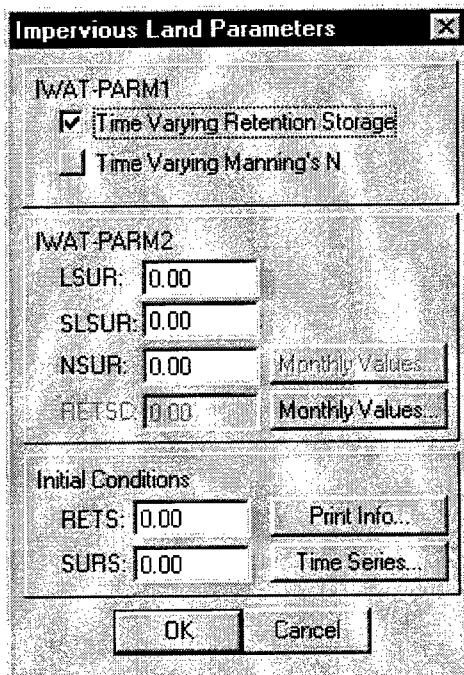
Figure 10. Impervious land parameters dialog box

IWAT PARM3

The values in this section of the dialog box are entered using toggle boxes. They tell HSPF what to expect while simulating the impervious land segments. The values are explained below.

- VRSFG indicates that retention storage capacity varies throughout the year. Selecting this toggle button undims the appropriate *Monthly Values...* button for entering the monthly values.

- VNNFG indicates that Manning's n for the overland flow plane varies throughout the year. Again, a button becomes undimmed allowing the user to input monthly values.

IWAT PARM2

The IWAT PARM2 values are explained in more detail below.

- LSUR is the length of the assumed overland flow plane.

- SLSUR is the slope of the assumed overland flow plane.

- NSUR is Manning's n for the overland flow plane.

- RETSC is the retention (interception) storage capacity of the surface.

Initial conditions

The initial conditions section is used to specify the initial water storages. The individual values are explained below.

- RETS is the retention storage.

- SURS is the surface (overland flow) storage.

These values help HSPF understand how to treat the water in the impervious land segment.

Pervious Sediment

The Pervious Sediment dialog box (Figure 11) allows the user to enter the values corresponding to sedimentation within the flow of water through the watershed. The pervious sedimentation variables are grouped into four categories: SED-PARM1, SED-PARM2, SED-PARM3, and SED-STOR. Each of these categories and their variables are explained in detail below.
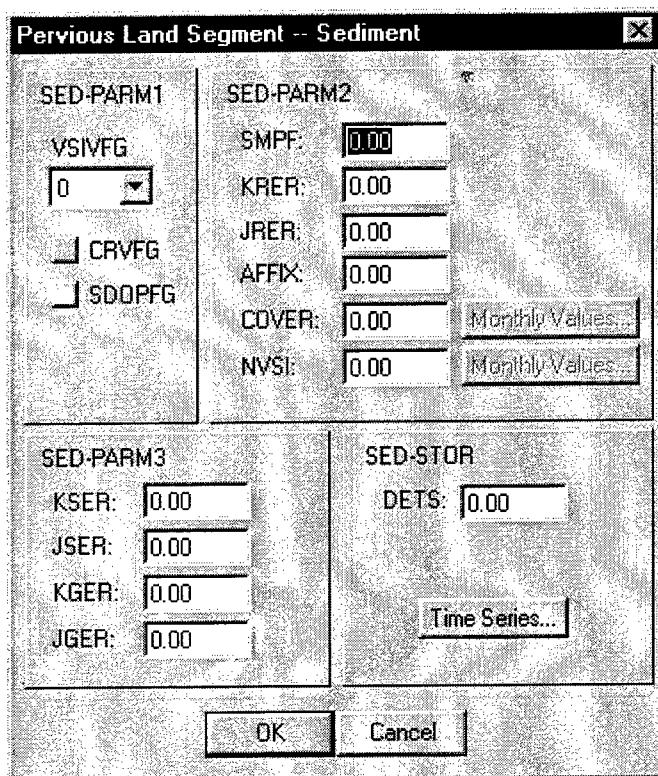
Figure 11. Pervious sediment dialog box

SED-PARM1

The variables in the SED-PARM1 section cover the method of sediment removal from the land surface.

- CRVFG indicates whether or not the erosion-related cover may vary throughout the year. A value of 1 indicates a variance, and a value of 0 indicates a constant value.

- VSIVFG indicates the rate of net vertical sediment input. If the value is 0, a constant net vertical sediment input is used. If 1, the net vertical sediment input may vary throughout the year. If a value of 2 is entered, the vertical sediment input is added to the detached sediment storage only on days when no rainfall occurred during the previous day.

- SDOPFG indicates the algorithm to be used to model the removal of sediment from the land surface. If a value of 1 is entered, the algorithm used in the ARM and NPS models is used. If a value of 0 is entered, the new algorithm will be used.

SED-PARM2

The parameters specified in the SED-PARM2 section involve erosion and how it is to be modeled in HSPF.

- SMPF is a "supporting management practice factor." It is used to simulate the reduction in erosion achieved by use of erosion control practices.

- KRER is the coefficient in the soil detachment equation.

- JRER is the exponent in the soil detachment equation.

- AFFIX is the fraction by which detached sediment storage decreases each day, as a result of soil compaction.

- COVER is the fraction of land surface that is shielded from erosion by rainfall (not considering snow cover, which can be handled by simulation).

- NVSI is the rate at which sediment enters detached storage from the atmosphere. A negative value can be supplied (e.g., to simulate removal by human activity or wind).

Monthly values may be supplied for the COVER and NVSI variables to allow for variance throughout the year. To access the *Monthly Values...*button, the user simply selects the toggle button that corresponds to the appropriate variable.

SED-PARM3

The parameters specified in the SED-PARM3 section affect how the simulation models scour and washoff.

- KSER is the coefficient in the detached sediment washoff equation.

- JSER is the exponent in the detached sediment washoff equation.

- KGER is the coefficient in the matrix soil scour equation.

- JGER is the exponent in the matrix soil scour equation.

KGER and JGER help simulate gully erosion, for example.

SED-STOR

The SED-STOR section has a single variable, DETS, which is used to describe the initial storage of detached sediment within the watershed.

Impervious Sediment

Clicking on the SOLIDS... button in the Impervious Land Activity dialog box accesses the Impervious Land Segment – Sediment dialog box (Figure 12). It allows the user to specify the appropriate parameters to simulate sedimentation within the runoff of the watershed. The parameters are divided into three

sections: SLD-PARM1, SLD-PARM2, and SLD-STOR. Each of the variables in these sections is explained below.
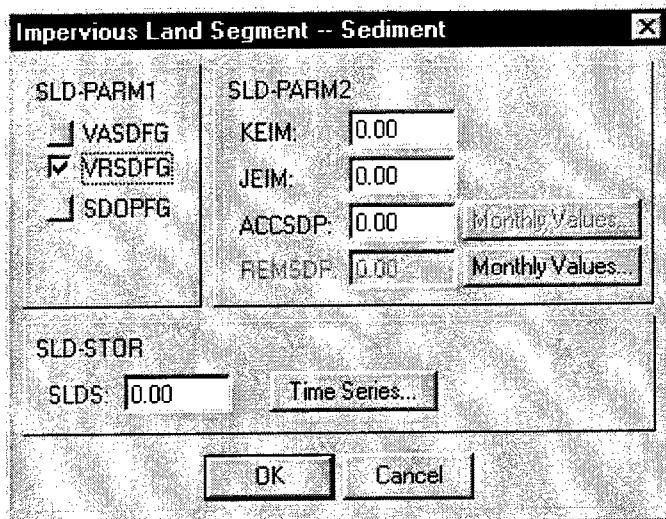
Figure 12. Impervious sediment dialog box

SLD-PARM1

This section of the dialog box contains the flags that indicate how the sedimentation is to be modeled.

- VASDFG indicates whether or not the accumulation rate of solids is allowed to vary throughout the year. If the value is 1, variance is allowed. If 0, the accumulation rate is considered a constant.

- VRSDFG indicates the unit removal rate. Again, varying with a value of 1 and constant with a value of 0.

- SDOPFG indicates which algorithm will be used to model the removal of sediment from the land surface. If 1, the algorithm in the NPS model is used. If 0, the new algorithm will be used.

SLD-PARM2

This section of the dialog box is related to how the solids are removed from or added to the land surface.

- KEIM is the coefficient in the solids washoff equation.

- JEIM is the exponent in the solids washoff equation.

- ACCSDP is the rate at which solids are placed on the land surface.

- REMSDP is the fraction of solids storage that is removed each day; when there is no runoff, for example, because of street sweeping.

If VASDFG and VRSDFG from the SLD-PARM1 section are set to 1, then the *Monthly Values...* buttons are undimmed for the accumulation and unit removal rates, and it is expected that varied monthly rates will be entered for these variables.

SLD-STOR

This section of the dialog box contains a single variable, SLDS, which is used to input the initial storage of solids in the watershed.

Pervious Water Quality

The Pervious Water Quality, PQUAL, dialog box (Figure 13) allows the user to specify up to 10 water quality constituents or pollutants in the outflows from a pervious land segment. The parameters in this dialog box are divided into three sections: NQUALS, QUAL-PROPS, and QUAL-INPUT. The variables from each of these sections are described below.
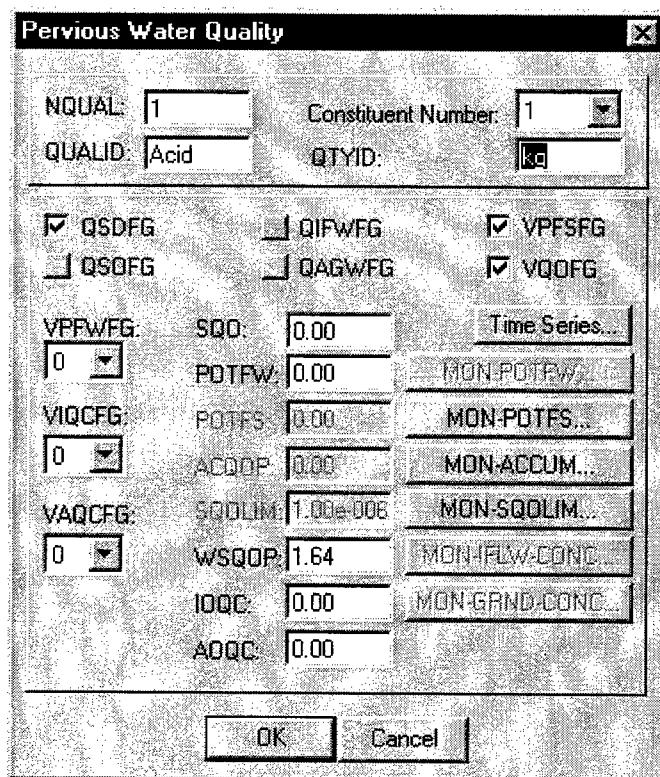
Figure 13.   Pervious water quality dialog box

NQUALS

This section contains a single variable that defines how many constituents will be modeled for this pervious land segment. Next to the box in which the user

enters the number of water quality constituents is a combo box that shows the user which constituent is currently being modeled by the input parameters.

QUAL-PROPS

This section of the dialog box is used to input the quality constituent identifiers and flags. Each of these is defined below.

- QUALID is a character string up to 10 characters that identifies the quality constituent.

- QTYID is a string up to four characters that identifies the units associated with this constituent.

- QSDFG identifies the association for the constituent. If this value is 1, then the constituent is sediment associated (QUALSD).

- VPFWFG is used to indicate whether or not the washoff potency factor may vary throughout the year. If a value of 1 is entered, it is variable. If 0, it is considered to be constant.

- VPFSFG is used to indicate whether or not the scour potency factor may vary throughout the year. If 1, it varies. If 0, it is constant.

- QSOFG identifies the association for the constituent. If this value is 1, then the constituent is directly associated with overland flow (QUALOF).

- VQOFG is used to indicate whether or not the rate of accumulation and the limiting storage of QUALOF may vary throughout the year. Again, a value of 1 indicates variance, and a value of 0 indicates constancy.

- QIFWFG identifies the association for the constituent. If this value is 1, then the constituent is interflow associated (QUALIF).

- VIQCFG is used to show variance of the constituent in interflow outflow. If the value is greater than 1, then the constituent varies throughout the year. If the value is 2 or 4, the daily values are obtained directly from the monthly values; no interpolation between monthly values is performed. If it is 3 or 4, the units of the input concentrations are mg/L.

- QAGWFG identifies the association for the constituent. If this value is 1, then the constituent is groundwater associated (QUALGW).

- VAQCFG indicates whether the concentration of this constituent in groundwater outflow may vary throughout the year or not. A value of 1 allows variance. A value of 2 or 4 indicates that the daily values are obtained directly from the monthly values; no interpolation between

monthly values is performed. If it is 3 or 4, the units of the input concentrations are mg/L.

QUAL-INPUT

This section of the dialog box allows the user to input the storage on the surface and the nonseasonal parameters. Each of the variables is explained below.

- SQO is the initial storage of QUALOF on the surface of the pervious land segment.

- POTFW is the washoff potency factor.

- POTFS is the scour potency factor.

- ACQOP is the rate of accumulation of QUALOF.

- SQOLIM is the maximum storage of QUALOF.

- WSQOP is the rate of surface runoff that will remove 90 percent of stored QUALOF per hour.

- IOQC is the concentration of the constituent in interflow outflow (meaningful only if this is a QUALIF).

- AOQC is the concentration of the constituent in active groundwater outflow (meaningful only if this is a QUALGW).

If monthly values are supplied for any of these quantities, then the value in the dialog box is not relevant.

Impervious Water Quality

The Impervious Water Quality dialog box (Figure 14) allows the user to simulate up to 10 water quality constituents for the impervious land segment. The dialog box and its variables are divided into three groups: NQUALS, QUAL-PROPS, and QUAL-INPUT. Each of these is explained in more detail below.
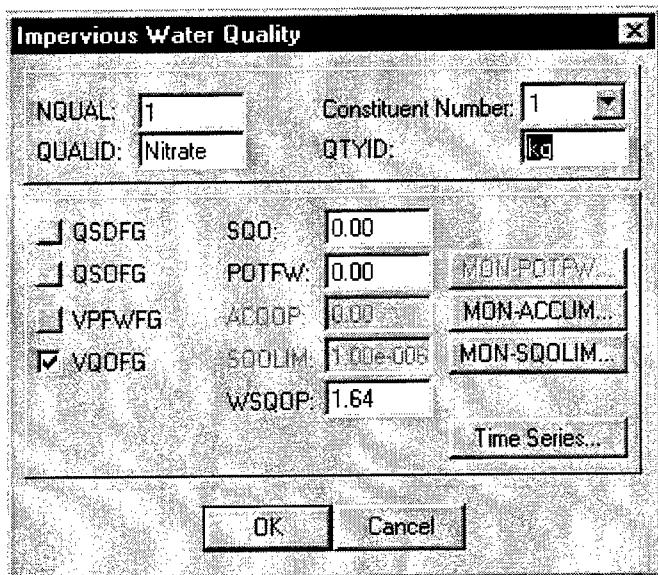
Figure 14. Impervious water quality dialog box

NQUALS

The NQUALS section has two boxes in it. One lets the user input the number of water quality constituents that will be modeled in this simulation. The other is a combo box to show which constituent is currently being modeled.

QUAL-PROPS

This section of the dialog box allows the user to specify the identifiers and flags for the constituent being modeled. Each of the variables will be described below.

- QUALID is the name of the constituent. It may contain up to 10 characters.

- QTYID is the unit associated with the constituent. This string may contain up to 4 characters.

- QSDFG is the flag that identifies whether or not the constituent is sediment associated. If the value is 1, then it is associated with sediment. If 0, it is not.

- VPFWFG indicates whether the washoff potency factor may vary throughout the year. A value of 1 indicates variance, and a value of 0 indicates constancy.

- QSOFG indicates that the constituent is directly associated with overland flow if the value is 1.

- VQOFG indicates whether or not the rate of accumulation and the limiting storage of QUALOF may vary throughout the year. A value of 1 indicates variance, and a value of 0 indicates constancy.

Reach/Reservoir Parameters

The Reach/Reservoir Parameters dialog box allows the user to input the variables that allow HSPF to simulate the hydraulic behavior through the reach/reservoir. The dialog box and its variables are divided into three sections: HYDR-PARM1, HYDR-PARM2, and HYDR-INIT. These will be explained below.
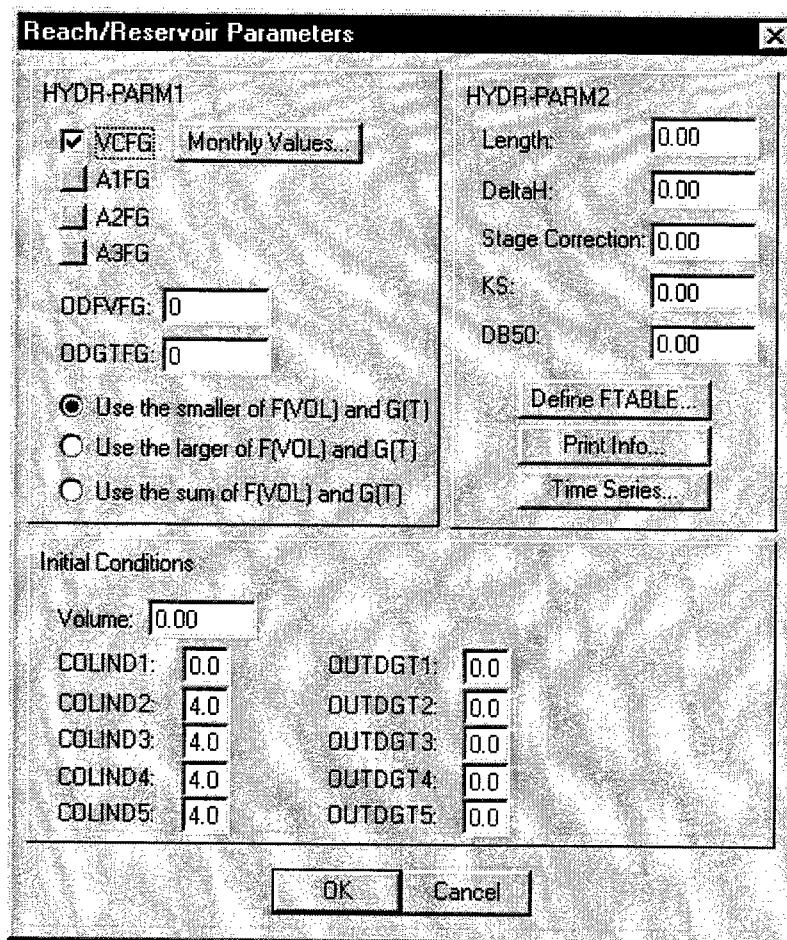
Figure 15. Reach/reservoir parameters dialog box

HYDR-PARM1

This section contains the flags that define how the reach/reservoir will be modeled in HSPF.

HYDR-PARM2

The parameters defined in this section relate to the geometry of the reach/reservoir. They are all explained below.

- LEN is the length of the RCHRES.

- DELTH is the drop in water elevation from the upstream to the downstream extremities of the RCHRES.

- STCOR is the correction to the RCHRES depth to calculate stage.

- DB50 is the median diameter of the bed sediment (assumed constant throughout the run). This value is not connected with the value for sand particle diameter supplied in the SEDTRN section. This value is used to:

  - Calculate the bed shear stress if the RCHRES is a lake.

  - Calculate the rate of sand transport if the Colby or Toffaleti methods are used.

HYDR-INIT

This section includes the parameters that define the initial conditions in the reach/reservoir.

- VOL is the initial volume of water in the RCHRES.

- COLIND is divided among the five possible exits, and it indicates the pair of columns used to evaluate the initial value of the F(VOL) component of outflow demand for the exit.

- OUTDGT is also divided among the five possible exits, and it specifies the G(T) component of the initial outflow demand for each exit from the RCHRES.

Define FTABLE

The button in the Reach/Reservoir Parameters that lets the user define the FTABLE for the RCHRES brings up a dialog box with a spreadsheet in it. The user then specifies the number of rows and columns in the spreadsheet. Then, the user fills in the values for the FTABLE.

ADCALC Data

From the Reach/Reservoir Activity dialog box, the user can access the ADCALC data dialog (Figure 16). The variables in this dialog box are used to prepare to simulate advection of entrained constituents.
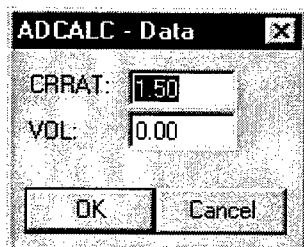
Figure 16. ADCALC –
data dialog box

- CRRAT is the ratio of maximum velocity to mean velocity in the RCHRES cross section under typical flow conditions.

- VOL is the volume of water in the RCHRES at the start of the simulation. Input of this value is not necessary if section HYDR is active.

HTRCH Input

The HTRCH Input dialog (Figure 17) is used to simulate heat exchange and water temperature. It is divided into two sections: HEAT-PARM and HEAT-INIT.
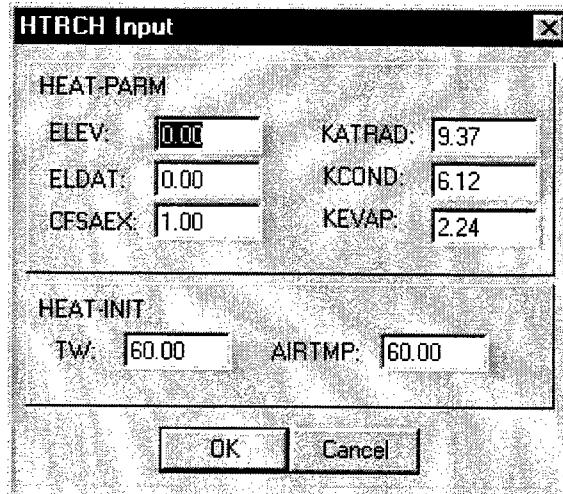
Figure 17. HTRCH input dialog box

HEAT-PARM

The values in HEAT-PARM cover general geometric and thermal data for the RCHRES.

- ELEV is the mean RCHRES elevation.

- ELDAT is the difference in elevation between the RCHRES and the air temperature gauge (positive if RCHRES is higher than the gauge).

- CFSAEX is the correction factor for solar radiation (it includes fraction of RCHRSE surface exposed to radiation).

- KATRAD is the long-wave radiation coefficient.

- KCOND is the conduction-convection heat transport coefficient.

- KEVAP is the evaporation coefficient.

HEAT-INIT

These variables are both temperature related.

- TW is the initial water temperature.

- AIRTMP is the initial air temperature at the RCHRES.

Reach/Reservoir – Sediment

This section is used to simulate the behavior of inorganic sediment in the water of the RCHRES. The SEDTRN dialog is divided into seven sections: SANDFG, SED-GENPARM, SED-HYDPARM, SAND-PM, SILT-CLAY-PM, SSED-INIT, and BED-INIT. Each of these sections is accessed by choosing it in the combo box on the left side of the dialog box (Figure 18).
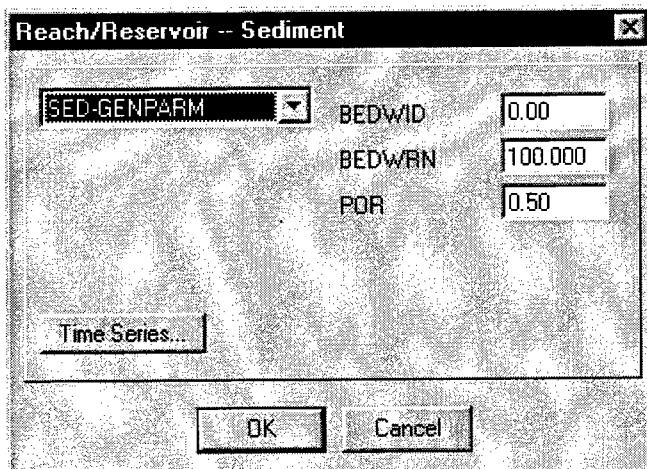
Figure 18. Reach/reservoir – sediment dialog box

SANDFG

This section contains a single variable, SDFG, which indicates the method that will be used for sandload simulations:

- Toffaleti Method.

- Colby Method.

- User-specified power function method.

SED-GENPARM

This section contains the general sediment-related parameters.

- BEDWID is the width of the cross section over which HSPF will assume bed sediment is deposited regardless of stage, top width, etc. It is used to estimate the depth of bed sediment (BEDDEP).

- BEDWRN is the bed depth which, if exceeded, will cause a warning message to be printed.

- POR is the porosity of the bed (volume voids/total volume). It is used to estimate bed depth.

SED-HYDPARM

These are parameters that are normally read into the HYDR module.

- LEN is the length of the RCHRES.

- DELTH is the change in water elevation through the RCHRES.

- DB50 is the mean particle diameter.

SAND-PM

These are parameters related to the sand in the sediment.

- D is the effective diameter of the transported sand particles.

- W is the corresponding fall velocity in still water.

- RHO is the density of the sand particles.

- KSAND is the coefficient in the sandload power function formula.

- EXPSAND is the exponent in the sandload power function formula.

The sand transport algorithms do not actually use D; they use DB50. D is included here for consistency with the input data supplied for cohesive sediment.

SILT-CLAY-PM

This section deals with parameters for silt or clay.

- D is the effective diameter of the particles.

- W is the corresponding fall velocity in still water.

- RHO is the density of the particles.

- TAUCD is the critical bed shear stress for deposition. Above this stress, there will be no deposition; as the stress drops below this value to zero, deposition will gradually increase to the value implied by the fall velocity in still water.

- TAUCS is the critical bed shear stress for scour. Below this value, there will be no scour; above it, scour will steadily increase.

- M is the erodibility coefficient of the sediment.

In general, TAUCD should be less than or equal to TAUCS. Note that the default values for W, TAUCD, TAUCS, and M have been set so that silt and clay will behave as "washload"; that is, material will settle at the rate implied by W, and there will be no scour; the material will behave like a conservative substance.

SSED-INIT

This parameter defines the initial concentrations of suspended sediment.

- SSED is the initial concentration (in suspension) of sand, silt, and clay.

BED-INIT

These parameters define the initial fractions of bed sediment.

- BEDDEP is the initial total depth (thickness) of the bed.

- Fracsand is the initial fraction (by weight) of sand in the bed material.

- Fracsilt is the initial fraction (by weight) of silt in the bed material.

- Fracclay is the initial fraction (by weight) of clay in the bed material.

The default values simulate an all-sand bed. The sum of the fractions must equal 1.00.

ReachRes Water Quality

This module is used to simulate the behavior of constituents involved in biochemical transformations. Unlike the other modules, this one has multiple sections that are each as involved as any other module. Those sections are OXRX, NUTRX, PLANK, and PHCARB, which model primary dissolved oxygen and biochemical oxygen demand balances, inorganic nitrogen and phosphorus balances, plankton populations and associated reactions, and pH and inorganic carbon species, respectively. The constituents that may be modeled using RQUAL are dissolved oxygen, biochemical oxygen demand, ammonia, nitrite, nitrate, orthophosphorus, phytoplankton, benthic algae, zooplankton, dead refractory organic nitrogen, dead refractory organic phosphorus, dead refractory organic carbon, pH, and carbon dioxide.

The ReachRes Water Quality dialog box (Figure 19) may be divided into two main sections: the overall water quality variables and the buttons leading to the four sections of the RQUAL module.
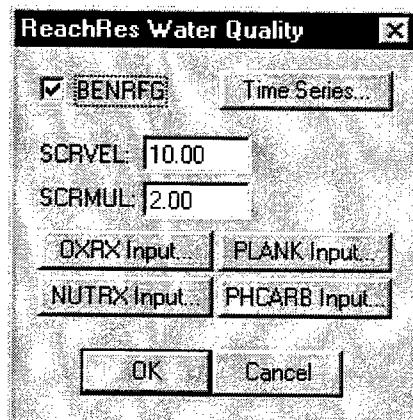
Figure 19. ReachRes water
           quality dialog box

Overall water quality variables

A toggle box at the top of the dialog box allows the user to indicate whether or not benthal influences will be considered while running the simulation. There are two text edit fields that handle the scouring parameters to be considered. SCRVEL is the velocity above which effects of scouring on benthal release rates is considered. SCRMUL is the multiplier to increase benthal releases during scouring.

RQUAL section buttons

The four buttons located at the bottom of the RQUAL dialog box lead to the four sections of the RQUAL module: OXRX, NUTRX, PLANK, and PHCARB.

OXRX Section of the RQUAL Module

This section is used to simulate the primary processes that determine the dissolved oxygen concentration in a reach or mixed reservoir. The dialog box (Figure 20) that handles this section of the module is composed of a combo box and several text edit fields. As an option is chosen within the combo box, different variables are expected. The options that may appear in the combo box are OX-FLAGS, OX-GENPARM, ELEV, OX-BENPARM, OX-CFOREA, OX-TSIVOGLOU, OX-LEN-DELTH, OX-TCGINV, OX-REAPARM, and OX-INIT.
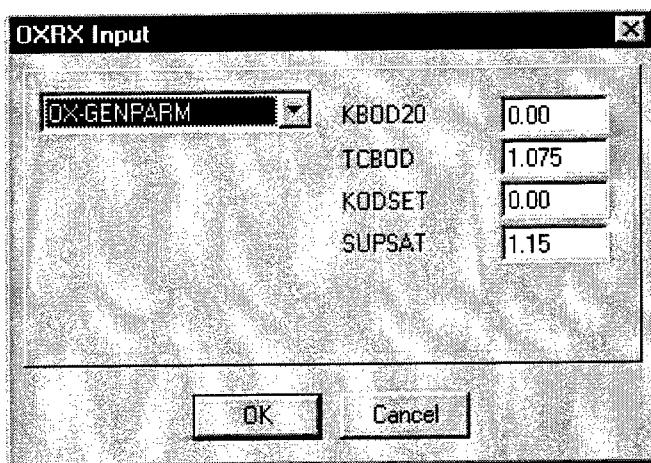
Figure 20. OXRX input dialog box

OX-FLAGS

There is one flag that is set within the OXRX section. REAMFG indicates the method used to calculate reaeration coefficient for free-flowing streams. A value of 1 means the Tsivoglou method is used. A value of 2 means that Owens, Churchill, or O'Connor-Dobbins method is used depending on velocity and depth of water. A value of 3 means that the coefficient is calculated as a power function of velocity and/or depth; user inputs exponents for velocity and depth and an empirical constant (REAK).

OX-GENPARM

This selection from the combo box will present the user with four text edit fields. The variables associated with those fields are related to the BOD to be modeled in the simulation. KBOD20 is the unit BOD decay rate @ 20 °C. TCBOD is the temperature correction coefficient for BOD decay. KODSET is the rate of BOD settling. SUPSAT is the allowable dissolved oxygen supersaturation (expressed as a multiple of DO saturation concentration).

ELEV

This selection from the combo box asks the user to input a single variable. ELEV is the RCHRES elevation above sea level. This option is only available if the HTRCH module is not active.

OX-BENPARM

This option, only available if the BENTH flag is selected in the main RQUAL dialog box, has the user input six variables related to the oxygen benthic parameters. BENOD is the benthal oxygen demand at 20 °C (with unlimited DO concentration). In this case, demand is proportional to the water temperature. TCBEN is the temperature correction coefficient for benthal oxygen demand. EXPOD is the exponential factor in the dissolved oxygen term of the benthal oxygen demand equation. BRBOD(1) is the benthal release of BOD at high oxygen concentration. BRBOD(2) is the increment to benthal release of BOD under anaerobic conditions. EXPREL is the exponential factor in the dissolved oxygen term of the benthal BOD release equation.

OX-CFOREA

This option, only available if LKFG = 1 in the general information section, asks for a single variable. CFOREA is the correction factor in the lake reaeration equation, to account for good or poor circulation characteristics.

OX-TSIVOGLOU

This option, only available if LKFG = 0 and REAMFG = 1, asks for the two variables required to run the Tsivoglou calculation. REAKT is the empirical constant in Tsivoglou's equation for reaeration (escape coefficient). TCGINV is the temperature correction coefficient for surface gas invasion.

OX-LEN-DELTH

This option, only available if LKFG = 0 and REAMFG = 1 and the HYDR section is inactive, allows the user to enter two variables describing the reach. LEN is the length of the RCHRES. DELTH is the energy drop over the length.

OX-TCGINV

This option, only available if LKFG = 0 and REAMFG = 2, allows the user to input the variable necessary to run the Owen/Churchill or O'Connor-Dobbins equations. TCGINV is the temperature correction coefficient for surface gas invasion.

OX-REAPARM

This option, only available if LKFG = 0 and REAMFG = 3, allows the user to input the four variables required for the user-supplied reaeration equation.

TCGINV is the temperature correction coefficient for surface gas invasion. REAK is the empirical constant for the equation used to calculate the reaeration coefficient. EXPRED is the exponent to depth used to calculate the reaeration coefficient. EXPREV is the exponent to velocity used to calculate the reaeration coefficient.

OX-INIT

This option allows the user to input the initial concentrations in the simulation. DOX is the dissolved oxygen initial concentration. BOD is the initial concentration of biochemical oxygen demand. SATDO is the dissolved oxygen saturation concentration.

NUTRX Section

This section of the RQUAL module simulates the primary processes that determine the balance of inorganic nitrogen and phosphorus in natural waters. Like the OXRX section, this dialog box (Figure 21) is comprised of a combo box with various text edit fields to enter the variables needed. There are nine possible options in the combo box: NUT-FLAGS, CONV-VAL1, NUT-BENPARM, NUT-NITDENIT, NUT-NH3VOLAT, NUT-BEDCONC, NUT-ADSPARM, NUT-ADSINIT, and NUT-DINIT.
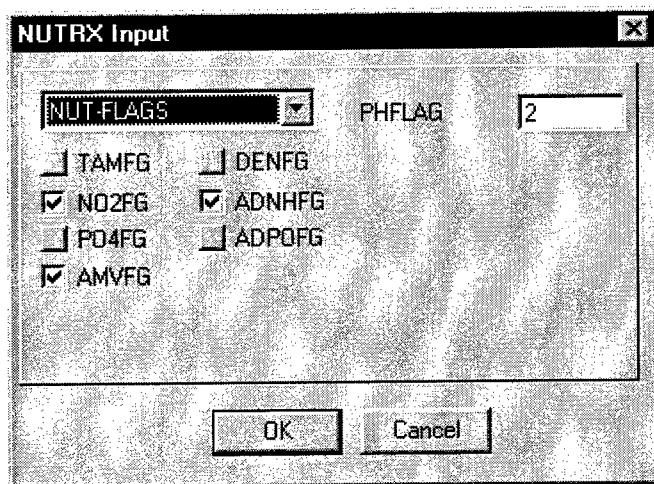
Figure 21. NUTRX input dialog box

NUT-FLAGS

This option brings up seven toggle boxes and a single text edit field. TAMFG is a toggle box that simulates total ammonia if chosen. NO2FG simulates nitrite if selected. PO4FG simulates orthophosphorus if selected. AMVFG enables ammonia vaporization if selected. DENFG enables denitrification if selected. ADNHFG simulates NH4 adsorption if selected. ADPOFG simulates PO4

adsorption if selected. PHFLAG is entered in the text edit field. It indicates the source of the pH data (1 = time series, 2 = constant, and 3 = monthly values).

CONV-VAL1

This option allows the user to input the required conversion factors. CVBO is the conversion from milligrams biomass to milligrams oxygen. CVBPC is the conversion from biomass expressed as phosphorus to carbon equivalency. CVBPN is the conversion from biomass expressed as phosphorus to nitrogen equivalency. BPCNTC is the percentage, by weight, of biomass that is carbon.

NUT-BENPARM

This option, only available if the BENTH flag is selected in the main RQUAL dialog box, allows the user to input the nutrient benthic parameters. BRTAM(1) is the benthal release of total ammonia using an aerobic rate. BRTAM(2) is the benthal release of total ammonia using an anaerobic rate. BRPO4(1) is the benthal release of orthophosphate using an aerobic rate. BRPO4(2) is the benthal release of orthophosphate using an anaerobic rate. ANAER is the concentration of dissolved oxygen below which anaerobic conditions exist.

NUT-NETDINIT

This option allows the user to input the nitrification and denitrification parameters. KTAM20 is the nitrification rate of ammonia at 20 °C. KNO220 is the nitrification rate of nitrite at 20 °C. KNO320 is the denitrification rate at 20 °C. TCNIT is the temperature correction coefficient for nitrification. TCDEN is the temperature correction coefficient for denitrification. DENOXT is the dissolved oxygen concentration threshold for denitrification.

NUT-NH3VOLAT

This option, only available if TAMFG and AMVFG are selected under NUT-FLAGS, allows the user to input the ammonia volatilization parameters. EXPNVG is the exponent in the gas layer mass transfer coefficient equation for NH3 volatilization. EXPNVL is the exponent in the liquid layer mass transfer coefficient equation for NH3 volatilization.

NUT-BEDCONC

This option, only available if TAMFG and ADNHFG are selected or if PO4FG and ADPOFG are selected, allows the user to input the bed concentrations of adsorbed NH3 and PO4. BNH4 is the constant bed concentration of NH4-N. It is required for sand, silt, and clay. BPO4 is the constant bed concentration of PO4-P. It is also required for sand, silt, and clay.

NUT-ADSPARM

This option, only available if TAMFG and ADNHFG are selected or if PO4FG and ADPOFG are selected, allows the user to input the partition coefficients of adsorbed NH3 and PO4. ADNHPM is the partition coefficient for NH4-N adsorbed to sand, silt, and clay. All three values are expected. ADPOPM is the partition coefficient for PO4-P adsorbed to sand, silt, and clay. Again, all three values are expected.

NUT-ADSINIT

This option, only available if TAMFG and ADNHFG are selected or if PO4FG and ADPOFG are selected, allows the user to input the initial concentrations of NH3 and PO4 adsorbed to suspended sediment. SNH4 is the initial concentration of NH4-N adsorbed to sand, silt, and clay. All three values are expected. SPO4 is the initial concentration of PO4-P adsorbed to sand, silt, and clay. Again, all three values are expected.

NUT-DINIT

This option allows the user to input initial concentrations of dissolved nutrients. NO3 is the initial concentration of nitrate. TAM is the initial concentration of total ammonia. NO2 is the initial concentration of nitrite (as N). PO4 is the initial concentration of orthophosphorus (as P). PHVAL is the constant (annual) or initial value of pH.

PLANK Section

This section of the RQUAL module simulates phytoplankton, zooplankton, and/or benthic algae. This section, like the others in the RQUAL module, contains a combo box (Figure 22) with text edit fields that appear asking for the appropriate variables. The sections are PLNK-FLAGS, SURF-EXPOSED, PLNK-PARM1, PLNK-PARM2, PLNK-PARM3, PHYTO-PARM, ZOO-PARM1, ZOO-PARM2, BENAL-PARM, and PLNK-INIT.
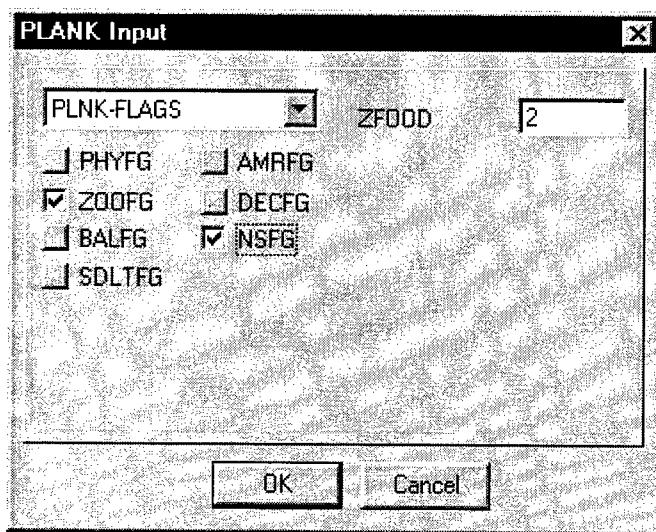
Figure 22. PLANK input dialog box

PLNK-FLAGS

This option brings up seven toggle boxes and a single text edit field allowing the user to indicate which simulations are to be run. PHYFG simulates phytoplankton when selected. ZOOFG simulates zooplankton when selected. BALFG simulates benthic algae if selected. SDLTFG simulates the influence of sediment washload on light extinction. AMRFG enables ammonia retardation of nitrogen-limited growth. DECFG decouples the linkage between carbon dioxide and phytoplankton growth. NSFG includes ammonia as part of the available nitrogen supply in nitrogen-limited growth calculations. ZFOOD is the quality of zooplankton food.

SURF-EXPOSED

This option, only available if HTRCH is not active, allows the user to input the correction factor for solar radiation data. CFSAEX is used to adjust the input solar radiation to make it applicable to the RCHRES. For example, it would account for shading of the surface by trees or buildings.

PLNK-PARM1

This option allows the user to input some general plankton parameters. RATCLP is the ratio of chlorophyll "A" content of biomass to phosphorus content. NONREF is the nonrefractory fraction of algae and zooplankton biomass. LITSED is the multiplication factor to total sediment concentration to determine sediment contribution to light extinction. ALNPR is the fraction of nitrogen requirements for phytoplankton growth satisfied by nitrate. EXTB is the base extinction coefficient for light. MALGR is the maximal unit algal growth rate.

PLNK-PARM2

This option allows the user to input more of the general plankton parameters. CMMLT is the Michaelis-Menten constant for light-limited growth. CMMN is the nitrate Michaelis-Menten constant for nitrogen-limited growth. CMMNP is the nitrate Michaelis-Menten constant for phosphorus-limited growth. CMMP is the phosphate Michaelis-Menten constant for phosphorus-limited growth. TALGRH is the temperature above which algal growth ceases. TALGRL is the temperature below which algal growth ceases. TALGRM is the temperature below which algal growth is retarded.

PLNK-PARM3

This option allows the user to input more of the general plankton parameters. ALR20 is the algal unit respiration rate at 20 °C. ALDH is the high algal unit death rate. ALDL is the low algal unit death rate. OXALD is the increment to phytoplankton unit death rate because of anaerobic conditions. NALDH is the inorganic nitrogen concentration below which high algal death rate occurs (as nitrogen). PALDH is the inorganic phosphorus concentration below which high algal death rate occurs (as phosphorus).

PHYTO-PARM

This option, only available if PHYFG is selected, allows the user to input phytoplankton parameters. SEED is the minimum concentration of plankton not subject to advection (i.e., at high flow). MXSTAY is the concentration of plankton not subject to advection at very low flow. OREF is the outflow at which concentration of plankton not subject to advection is midway between SEED and MXSTAY. CLALDH is the chlorophyll "A" concentration above which high algal death rate occurs. PHYSET is the rate of phytoplankton settling. REFSET is the rate of settling for dead refractory organics.

ZOO-PARM1

This option, only available if PHYFG and ZOOFG are selected, allows the user to input the first group of zooplankton parameters. MZOEAT is the maximum zooplankton unit ingestion rate. ZFIL20 is the zooplankton filtering rate at 20 °C. ZRES20 is the zooplankton unit respiration rate at 20 °C. ZD is the natural zooplankton unit death rate. OXZD is the increment to unit zooplankton death rate because of anaerobic conditions.

ZOO-PARM2

This option, only available if PHYFG and ZOOFG are selected, allows the user to input the second group of zooplankton parameters. TCZFIL is the temperature correction coefficient for filtering. TCZRES is the temperature correction coefficient for respiration. ZEXDEL is the fraction of nonrefractory zooplankton excretion that is immediately decomposed when ingestion rate > MZOEAT. ZOMASS is the average weight of a zooplankton organism.

BENAL-PARM

This option, only available if BALFG is selected, allows the user to input the benthic algae parameters. MBAL is the maximum benthic algae density (as biomass). CFBALR is the ratio of benthic algal to phytoplankton respiration. CFBALG is the ratio of benthic algal to phytoplankton growth rate.

PLNK-INIT

This option allows the user to set the initial plankton conditions. PHYTO is the initial phytoplankton, as biomass. ZOO is the initial zooplankton. BENAL is the initial benthic algae, as biomass. ORN is the initial dead refractory organic nitrogen. ORP is the initial dead refractory organic phosphorus. ORC is the initial dead refractory organic carbon.

PHCARB Section

This section of the RQUAL module simulates pH, carbon dioxide, total inorganic carbon, and alkalinity in the RCHRES. Like the other sections of this module, the dialog box (Figure 23) contains a combo box for selecting one of the three sections: PH-PARM1, PH-PARM2, and PH-INIT. Text edit fields appear to allow input of the required variables.
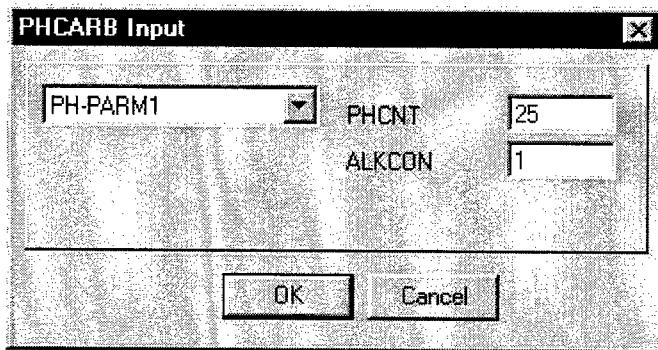
Figure 23.   PHCARB input dialog box

PH-PARM1

This option allows the user to set the appropriate flags for the pH simulation. PHCNT is the maximum number of iterations to pH solution. ALKCON is the number of conservative substances that are alkalinity.

PH-PARM2

This option allows the user to input the parameters of the pH simulation. CFCINV is the ratio of carbon dioxide invasion rate to oxygen reaeration rate. BRCO2(1) is the benthal release of CO_2 (as carbon) for aerobic conditions. BRCO2(2) is the benthal release of CO_2 (as carbon) for anaerobic conditions.

PH-INIT

This option allows the user to input the initial conditions for the pH simulation. TIC is the initial total inorganic carbon. CO2 is the initial carbon dioxide (as carbon). PH is the initial pH.

WDM Time Series

In order to run HSPF, certain time series must be defined. These time series are found within a WDM file, which is usually input into the *HSPF Global Options* dialog box. On many of the aforementioned dialog boxes, the user will find a *Time Series...* button. Upon clicking that button, the *Assign Time Series* dialog box (Figure 24) is activated.
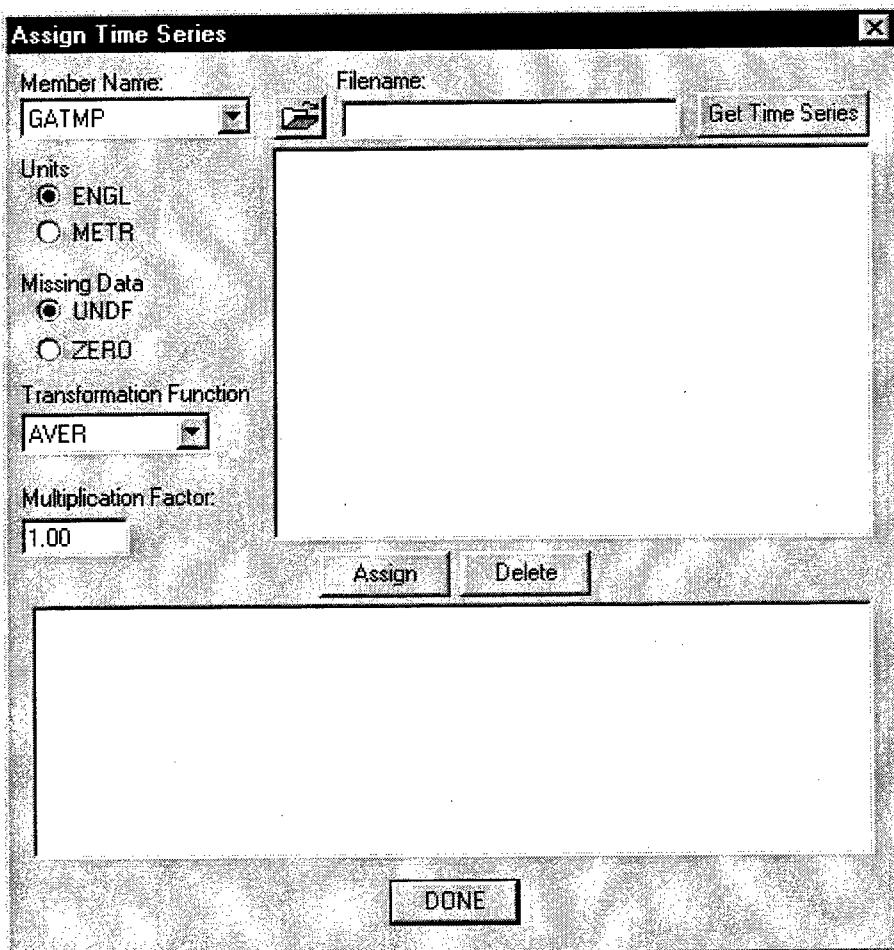

Figure 24.   Assign time series dialog box

This dialog box allows the user to input the various time series that will be used in the simulation. The user selects the member name, the units of the values in the time series, how missing data are to be treated, the transformation function, and a multiplication factor for any necessary unit conversions. The user will then

select a time series in the right text window and hit the *Assign* button. This will store that time series link in the lower text window. These time series will be written into the UCI file for HSPF to run the proper simulation.

Saving/Reading the HSPF Input File

While working on the definition of HSPF parameter, or when finished, the user may want to save the data. The *Save HSPF File* item in the *HSPF* menu saves all HSPF input data to an HSPF input file. The format of this file is consistent with that defined in the HSPF user's manual. This file may be named anything the user chooses, but generally has the *uci* extension. Note that the HSPF input file does not save any map data; though the map data are not necessarily needed, it may be saved in a Map file using the *Save As* command in the *File* menu.

Once an HSPF file has been saved, it may be read in later using the *Read HSPF File* command. Reading this file will build a topological tree and assign the HSPF parameters to the tree. Then the parameters may be edited as described above.

Running HSPF

Once the data for HSPF input has been defined, the HSPF model may be launched from WMS. The *Run HSPF* item in the *HSPF* menu will invoke the following dialog.

The *Run HSPF* dialog will allow the user to specify the input file, which is necessary to run *HSPF*. All other files required to run HSPF and to view the output were defined in the *HSPF Global Options* dialog box.

Once the input file has been defined and you select OK, *HSPF* will be executed. A separate window will appear, and information about the *HSPF* simulation will be reported. If you are running with Microsoft Windows, you must close this window when *HSPF* terminates.

If *HSPF* is not executed successfully when issuing this command, be sure that the path to the HSPF.EXE file is correct. If *HSPF* does not run to a successful completion, you can view the ASCII output file using the *View File* command in the *File* menu.

Reading in the HSPF Output Data

WMS can read in the output data that were created by HSPF during the simulation. The data appear in the hydrograph window, which is accessed by selecting *Show Hydrograph Window* in the *Edit* menu of the *Hydrologic Tree Module*.

The output data are stored in the WDM file when created by HSPF. In order to view the output, open the *View HSPF Output* dialog box by going to the *View Output...* command in the *HSPF* menu. The dialog box is similar to the others used in the interface. The user should make sure the proper WDM file is listed in the file name edit field. If not, the user should either type in the path and file name of the file or use the file browse button to find the file. Once the file is loaded and the time series are read in, the user can simply select the proper output series, and it will be displayed.

2   HSPF Tutorial

Estimated Time: 30 min

Once a watershed has been delineated and subdivided into subbasins, WMS may be used to define the parameters necessary for HSPF computations. WMS will automatically calculate geometric attributes such as areas, lengths, and slopes; however, parameters such as constituents, pH, and sedimentation must be entered or computed through a series of interactive dialog boxes. Once the parameters needed to define an HSPF model have been defined, an input file with the proper format for HSPF may be written automatically, and HSPF may be launched directly from WMS. There is no need to use a text editor or even look at the file.

Most of the necessary operations to define an HSPF model are reviewed in this tutorial; however, you are encouraged to explore the different available options of each dialog, being sure to select the given method and values before exiting the dialog.

Objectives

In this tutorial you will read a Map file into WMS; this file contains a watershed delineated from a DEM in northern Utah. Then you will be instructed on how to define the necessary parameters for HSPF computations. The steps covered include the following:

- Reading Map data files.

- Defining geometric attributes of the watershed.

- Choosing job control and output options for HSPF.

- Defining the individual water quality parameters for each basin segment.

- Creating an HSPF input file.

- Running HSPF.

- Reading in solution files and displaying results from HSPF.

Reading the Data Files

A Map file is a WMS specific file that contains feature object data such as polygons, arcs, and points. For this tutorial, the Map file contains a rural watershed that has been divided into several subareas. Drain lines have been established and collection points defined also. To read in the file, do the following:

1. If you are continuing from a previous tutorial, select *New* from the *File* menu and confirm that all data should be deleted.

2. Select the *Map Module* icon .

3. Select *Open* command from the *File* menu.

4. Find and open the file named *aspen.map*. This file should be located in the tutorial directory.

When the file is read in, you should see a watershed divided into one subbasin along with the corresponding topological tree.

Computing Geometric Attributes

Some of the geometric attributes are not saved as part of the Map file; therefore, you should be sure to compute them each time you wish to define an HSPF input file.

1. Select the *Update Basin Data* command from the *Feature Objects* menu.

2. Specify feet for the model units, acres for area, feet for distance, and then select the OK button.

After the computation, the basin areas will be displayed at the centroid of the drainage basin. Once computed, basin areas, stream lengths, and stream slopes are automatically stored for use in defining the HSPF input.

Defining Global Options

Now that the basin data have been updated, it is time to input the necessary HSPF parameters. These options include how many days the simulation is to run and what input files are to be used. To define these options:

1. Click on the *Select Drainage Basin* tool .

2. Select HSPF Global Options... from the HSPF menu.

3. When the dialog appears, input a title for the simulation, the output level requested, the required file names for input and output, and click the *Initialize HSPF Data* button. Once clicked, the time buttons will become available. Use them to input the starting and ending times for the simulation

4. You may leave the Input Files at their default values.

5. Click *OK* to exit.

The Global Options have now been defined, and the HSPF data have been initialized for each basin segment and RCHRES.

Defining Basin Parameters

HSPF basin parameters that can be defined using *WMS* include area, slope, and length. Most of these variables may be defined automatically by WMS.

To inspect the needed parameters for a basin, do the following:

1. Double-click Basin 1B on the tree to open the *Edit HSPF Attributes* dialog box. It is also possible to access this dialog box by selecting the basin and choosing *Edit HSPF Attributes...* from the *HSPF* menu.

2. Select the basin segment within the basin segments window and input 0.77 into the segment area field below the *Define Activities...* button to the left. Make sure the Pervious Land Segment radio button is selected.

3. Click on the *Add* button below the basin segments window. This will define a second segment within the basin.

4. Enter an area of 0.1 into its area field, and click on the Impervious Land Segment radio button.

Basin areas have already been computed when the geometric attributes were updated above. The area of this basin, computed as 0.87 mi^2 by WMS, appears at the top of the dialog box. Below it may be found the sum of the areas of the individual basin segments within the basin. The area calculated by WMS and that provided by summing the areas of the individual basin segments at the top of the dialog box should now be equal.

- Before moving on, you may want to inspect the *Edit HSPF Attributes* dialog. This is the main dialog created for defining HSPF data; both basin and reach data will be defined using this dialog. Try selecting any basin or reach on the tree or the map display while the dialog is up; the relevant data will be highlighted as you select different objects.

Define Basin Activities

Select Basin 1B in the hydrologic tree window. Select the first segment in the basin segments window. Select the *Define Activities...* button. This will bring up the *Pervious Land Activity* dialog box. Note that at present only three of the toggle boxes may be clicked. The other modules will be added at a later date.

1. Click on the toggle box next to the *PWAT...* button. This will undim the *PWAT...* button.

2. Click the *PWAT...* button. This will bring up the *Pervious Land Parameters* dialog box.

3. Click on the toggle buttons for *Time Varying Upper Zone Nominal Storage* and for *Time Varying Interflow Recession*. Note that the text edit fields for *UZSN* and *IRC* have been dimmed and the accompanying buttons are now free to be clicked.

4. Enter the following values in the appropriate fields: LZSN 0.01, INFILT 0.0001, LSUR 150.0, KVARY 0.0, AGWRC 0.001, INFEXP 2.0, INFILD 2.0, DEEPFR 0.0, BASETP 0.0, AGWETP 0.0, CEPSC 0.0, NSUR 0.05, INTFW 0.0001, LZETP 0.1, CEPS 2.0, SURS 3.0, UZS 0.001, IFWS 0.0, LZS 0.001, AGWS 10.0, and GWVS 5.0. Notice that the SLSUR value was filled in with the number calculated by WMS.

5. Click on the *Monthly Values...* button next to the UZSN edit field and enter the following values starting with January: 5.0, 4.0, 3.0, 2.0, 1.0, 0.7, 0.5, 0.4, 0.7, 1.0, 2.0, and 3.5.

6. Click *OK* to close the *Monthly Values* dialog box.

7. Click on the *Monthly Values...* button next to the IRC edit field and enter the following values starting with January: 0.1, 0.08, 0.05, 0.03, 0.01, 0.007, 0.002, 0.002, 0.001, 0.008, 0.02, and 0.08.

8. Click *OK* to close the *Monthly Values* dialog.

9. Click on the toggle box next to the *SEDMNT...* button. This will undim the button.

10. Click the *SEDMNT...* button. This will bring up the *Pervious Sediment* dialog box.

11. Enter the following values into the appropriate fields: SMPF 1.0, KRER 0.0, JRER 1.0, AFFIX 0.4, COVER 0.1, NVSI 0.2, KSER 0.0, JSER 1.0, KGER 0.0, JGER 1.0, and DETS 0.2.

12. Click *OK* to close the *Pervious Sediment* dialog box.

13. We will not be modeling a water quality constituent for this segment, but will do so in the Impervious section of the input. The method is the same for both land-use types.

Click on *OK* to close the *Pervious Land Activity* dialog box.

Select the second basin segment in the basin segment window. Make sure the Impervious Land Segment radio button is selected, and click the *Define Activities...* button. This will bring up the *Impervious Land Activity* dialog box. Again, only three of the modules may be activated at present.

1. Click on the toggle box next to the *IWAT...* button. This will undim the button.

2. Click the *IWAT...* button. This will bring up the *Impervious Land Parameters* dialog box.

3. Enter the following values in the appropriate edit fields: LSUR 120.0, NSUR 0.1, RETSC 2.0, RETS 0.001, and SURS 0.001. Note that the value for SLSUR was calculated by WMS and input in the edit field.

4. Click *OK* to close the *Impervious Land Parameters* dialog box.

5. Click on the toggle box next to the *SOLIDS...* button. This will undim the button.

6. Click the *SOLIDS...* button. This will bring up the *Impervious Sediment* dialog box.

7. Enter the following values into the appropriate fields: KEIM 1.0, JEIM 0.5, ACCSDP 0.1, REMSDP 0.6, and SLDS 0.1.

8. Click *OK* to close the *Impervious Sediment* dialog box.

9. Click on the toggle box next to the *IQUAL...* button. This will undim the button.

10. Click the *IQUAL...* button. This will bring up the *Impervious Water Quality* dialog box.

11. Enter the following values into the appropriate fields: QUALID 'nitrate', QTYID 'lb', SQO 0.2, POTFW 0.4, ACQOP 0.1, SQOLIM 0.00001, and WSQOP 1.64. Select the QSDFG toggle box as well.

12. Click *OK* to close the *Impervious Water Quality* dialog box.

Click *OK* to close the *Impervious Land Activity* dialog box.

Defining Reach Parameters

Each reach, or conveyance, in the watershed must have various parameters defined so that HSPF will properly route the flow through the watershed. WMS automatically defines several of these parameters, but not all of them. To define the necessary reach data, do the following:

1. Click on the circle labeled 1C on the tree to activate that portion of the *Edit HSPF Attributes* dialog related to that RCHRES.

2. Click on the *Define Activities...* button to bring up the *Reach/Reservoir Activity* dialog box.

3. Note that at present, two of the modules may not be activated in this dialog box.

4. Click on the toggle button to activate the *HYDR...* button.

5. Click on the *HYDR...* button to bring up the *Reach/Reservoir Parameters* dialog box.

6. Enter the following values into the appropriate fields: STCOR 0.0, KS 0.4, DB50 .01, VOL 12.0, COLIND[all] 4.0, OUTDGT[all] 1.0.

7. Click on the *Define FTABLE...* button to activate the *FTABLE* dialog box.

8. Enter a value of 4 in the *Number of rows* field.

9. In the first row, enter these values from left to right: 0.0, 0.0, 0.0, 0.0.

10. In the second row, enter these values: 5.0, 10.0, 25.0, 20.5.

11. In the third row, enter these values: 20.0, 120.0, 1000.0, 995.0.

12. In the fourth row, enter these values: 50.0, 400.0, 5000.0, 1000.0.

13. Click *OK* to close the *FTABLE* dialog box then *OK* on the *Reach/Reservoir Parameters* dialog box to close them.

14. Click on the toggle button to activate the *ADCALC...* button.

15. Click on the *ADCALC...* button to bring up the *ADCALC-Data* dialog box.

16. Enter these values in the appropriate fields: CRRAT 1.5 and VOL 12.0.

17. Click *OK* to close the *ADCALC-Data* dialog box.

18. Click on the toggle box to activate the *HTRCH...* button.

19. Click on the *HTRCH...* button to bring up the *HTRCH Input* dialog box.

20. Enter the following values in the appropriate fields: ELEV 2000.0, ELDAT 150.0, CFSAEX 1.0, KATRAD 9.37, KCOND 6.12, KEVAP 2.24, TW 60.0, and AIRTMP 60.0.

21. Click *OK* to close the *HTRCH Input* dialog box.

22. Click on the toggle box to activate the *SEDTRN...* button.

23. Click on the *SEDTRN...* button to bring up *the Reach/Reservoir – Sediment* dialog box.

24. Select *SANDFG* in the combo box, and enter the following value in the edit field: SANDFG 2.

25. Select *SED-GENPARM* in the combo box, and enter the following values in the appropriate fields: BEDWID 10.0, BEDWRN 35.0, and POR 0.5.

26. Select *SAND-PM* in the combo box, and enter the following values in the appropriate fields: D 0.01, W 0.02, RHO 2.65, KSAND 0.0, and EXPSND 0.0.

27. Select *SILT-PM* in the combo box, and enter the following values in the appropriate fields: D 0.002, W 0.1, RHO 2.65, TAUCD 0.0002, TAUCS 0.0001, and M 0.5.

28. Select *CLAY-PM* in the combo box, and enter the following values in the appropriate fields: D 0.001, W 0.05, RHO 2.65, TAUCD 0.0002, TAUCS 0.0001, and M 0.3.

29. Select *SSED-INIT* in the combo box, and enter the following values in the appropriate fields: Sand SSED 0.5, Silt SSED 0.2, Clay SSED 0.6.

30. Select *BED-INIT* in the combo box, and enter the following values in the appropriate fields: BEDDEP 0.2, fracsand 0.5, fracsilt 0.2, fracclay 0.3.

31. Click *OK* to close the *Reach/Reservoir – Sediment* dialog box.

32. Click on the toggle box to activate the *RQUAL...* button.

33. Click on the *RQUAL...* button to bring up the *ReachRes Water Quality* dialog box. The default values that are in the dialog box will be used in this tutorial.

34. Click on the *OXRX Input...* button to activate the *OXRX Input* dialog box.

35. The *OX-FLAGS* selection should be the default selection in the combo box, and the default value in the edit field is 2. These are acceptable for this simulation.

36. Select *OX-GENPARM* in the combo box, and enter these values in the appropriate fields: KBOD20 0.002, TCBOD 1.075, KODSET 0.1, SUPSAT 1.15.

37. Select *OX-TCGINV* in the combo box, and enter this value in the edit field: TCGINV 1.047.

38. Select *OX-INIT* in the combo box, and enter these values in the appropriate fields: DOX 2.0, BOD 1.5, SATDO 10.0.

39. Click *OK* to close the *OXRX Input* dialog box.

40. Click on the *NUTRX Input...* button to open the *NUTRX Input* dialog box.

41. Click on the toggle boxes for *TAMFG* and *AMVFG*.

42. Select *CONV-VAL1* in the combo box, and enter these values in the appropriate fields: CVBO 1.98, CVBPC 106.0, CVBPN 16.0, and BPCNTC 49.0.

43. Select *NUT-NITDENIT* in the combo box, and enter these values in the appropriate fields: KTAM20 0.05, KNO220 0.02, TCNIT 1.07, KNO320 0.1, TCDEN 1.07, and DENOXT 2.0.

44. Select *NUT-NH3VOLAT* in the combo box, and enter these values in the appropriate fields: EXPNVG 0.5 and EXPNVL 0.7.

45. Select *NUT-DINIT* in the combo box, and enter these values in the appropriate fields: NO3 0.5, TAM 0.2, NO2 0.0, PO4 0.5, and PHVAL 6.2.

46. Click *OK* to close the *NUTRX Input* dialog box.

47. Click the *PLANK Input...* button to activate the *PLANK Input* dialog box.

48. For this simulation, we will not turn any of the plankton flags on, but will just enter necessary values. Select *PLNK-PARM1* in the combo box, and enter these values in the appropriate fields: RATCLP 0.6, NONREF 0.5, LITSED 0.0, ALNPR 1.0, EXTB 0.02, and MALGR 0.3.

49. Select *PLNK-PARM2* in the combo box, and enter these values in the appropriate fields: CMMLT 0.033, CMMN 0.045, CMMNP 0.0284, CMMP 0.015, TALGRH 95.0, TALGRL 43.0, and TALGRM 77.0.

50. Select *PLNK-PARM3* in the combo box, and enter these values in the appropriate fields: ALR20 0.004, ALDH 0.01, ALDL 0.001, OXALD 0.03, NALDH 0.0, and PALDH 0.0.

51. Select *PLNK-INIT* in the combo box, and enter these values in the appropriate fields: PHYTO 0.00096, ZOO 0.03, BENAL 0.000008, ORN 0.0, ORP 0.0, and ORC 0.0.

52. Click *OK* to close the *PLANK Input* dialog box.

53. Click the *PHCARB Input...* button to active the *PHCARB Input* dialog box.

54. Select *PH-PARM1* in the combo box, and enter these values in the appropriate fields: PHCNT 25 and ALKCON 1.

55. Select *PH-PARM2* in the combo box, and enter these values in the appropriate fields: CFCINV 0.913, BRCO2(1) 62.0, and BRCO2(2) 62.0.

56. Select *PH-INIT* in the combo box, and enter these values in the appropriate fields: TIC 0.0, CO2 0.0, and PH 6.5.

57. Click *OK* to close the *PHCARB Input* dialog box, then click *OK* to close the *ReachRes Water Quality* dialog box.

The parameters needed for reach definition are now complete.

Saving the Input File and Running HSPF

Now that all the data are defined for HSPF, you will want to save it. The *Save HSPF File...* menu item in the *HSPF* menu may be used to save an HSPF file at any time, complete or not, for use later. However, the *Run HSPF* menu command also saves the input file and runs HSPF. This is the procedure you will need to do for this tutorial:

1. Select *Run HSPF* from the *HSPF* menu.

2. Verify that the file name selected in the *HSPF Global Options* dialog box is showing in the top or click the browse button to find the file.

3. Click on the toggle box to save the output file before running HSPF.

4. Click on *OK* to write the input file named *output.uci* and launch HSPF.

You will see a DOS window come up when HSPF begins running. You should see progress reports from HSPF in this window. Since you selected Days 3 and 4 for job control, you will see HSPF cycle through all the basins and reaches twice. When HSPF reports it is finished, select *Yes* to close the window.

To view the output, select *View HSPF Output...* from the *HSPF* menu. Verify that the WDM file name is in the edit field, and press the *Get Time Series* button. Choose the appropriate output time series, and click the *View Output* button. The output will appear in the hydrograph window.

Conclusion

This concludes the tutorial on defining HSPF files and displaying hydrographs. The concepts learned include the following:

- Reading Map data files.

- Defining geometric attributes of the watershed.

- Choosing global options for HSPF.

- Defining basin and reach/reservoir parameters.

- Creating an HSPF input file.

- Running HSPF.

- Reading in solution files and displaying results from HSPF.

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The integration of the watershed water quality model Hydrologic Simulation Program—FORTRAN (HSPF) into the Watershed Modeling System (WMS) was initiated as part of an overall goal of the Water Quality Research Program to provide water quality capabilities within the framework of a comprehensive graphical modeling environment for conducting hydrologic and water quality analysis. The WMS interface creates a way for the user to input a multitude of parameters into the input file and then to run HSPF to get the required output. The input parameters are linked to all the tools within WMS, including automated basin delineation and parameter definition using a graphical user interface. The objective of the interface developed in WMS is to provide graphical representation of HSPF data, as well as automate the definition of many of the required parameters. Many of the basic variables required for HSPF input are computed as part of WMS's basic functionality; additionally, specialty functions have been added to WMS to enable the usage of HSPF directly with data output from WMS. This report describes the initial linkage of HSPF into the WMS.

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